(12) UK Patent Application (19) GB (11) 2 072 359 A

(21) Application No 8104506
(22) Date of filing 13 Feb 1981
(30) Priority data
(31) 55/016272
(32) 13 Feb 1980
(31) 55/069874
(32) 26 May 1980
(33) Japan (JP)
(43) Application published
30 Sep 1981
(51) INT CL³
G03B 15/05 17/18
(52) Domestic classification
G2A 106 110 120 903 BJ
C16 C18 C19 C1 C23 C27
C30 CS
(56) Documents cited
GB 2060288A
GB 1519183A
(58) Field of search
G2A
G2X

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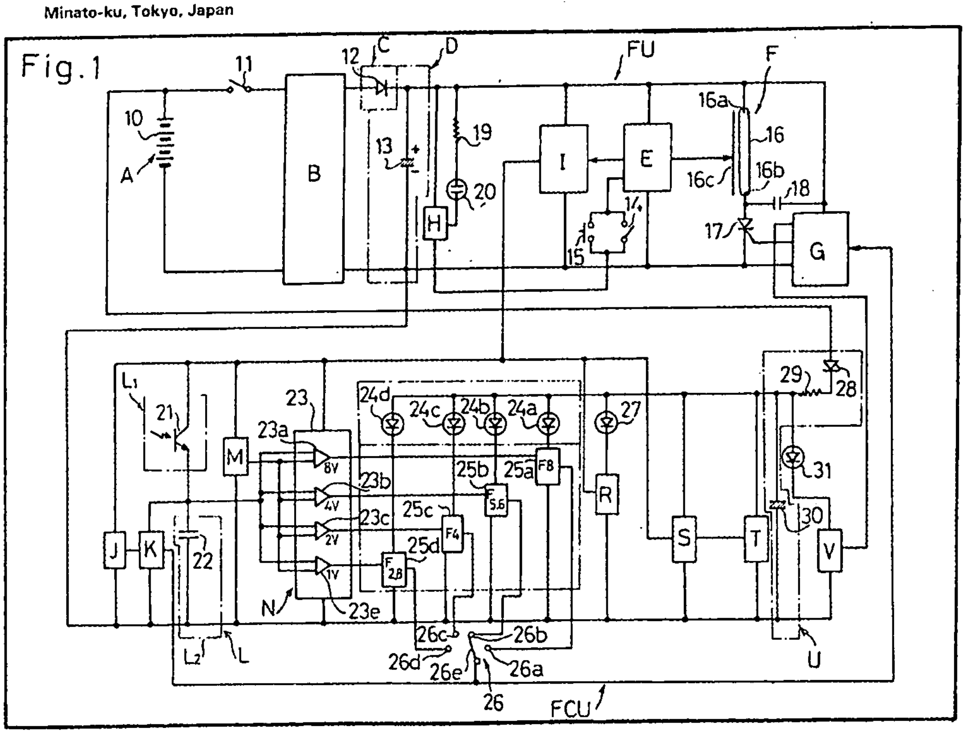
(54) Electronic Flash

(57) When a flash tube 16 is fired, reflected light is detected at 21 and integrated at 22, and the integrated level is compared with different reference levels by comparators 23 a-e. As shown, the comparators control respective switching circuits which energize LEDs 24a-d to indicate a suitable camera aperture value. A change over switch 26 connects a selected switching circuit to a flash quenching circuit G.

Fig.1



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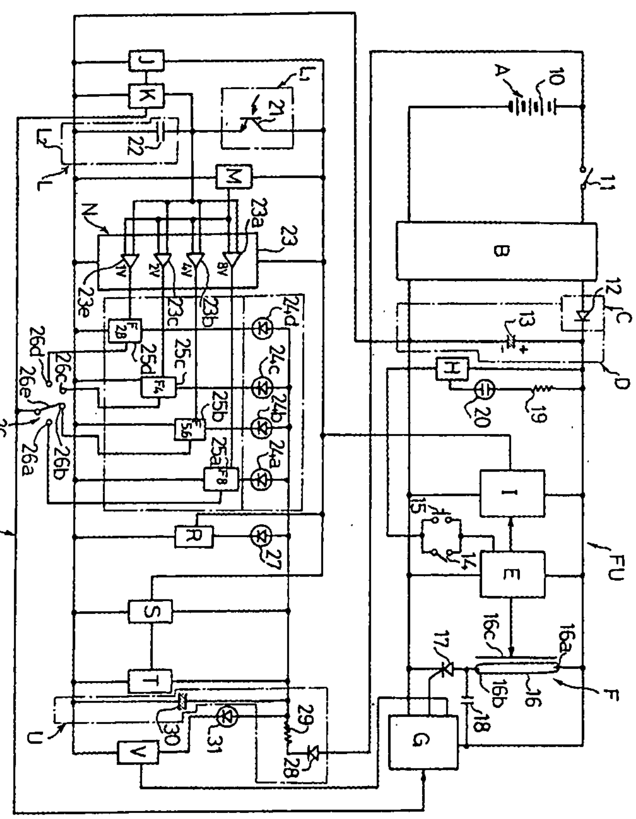
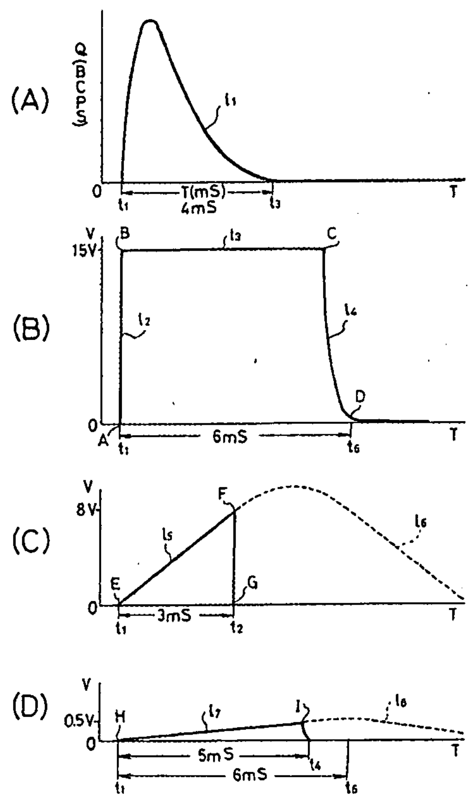


Fig.1

Fig. 2


(A)
Q(BCDS)
l_1
0
T(mS)
4mS
t_1
t_3
T
(B)
V
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B
C
l_3
l_2
l_4
D
0
A
6mS
t_1
t_6
T
(C)
V
8V
F
l_5
l_6
E
G
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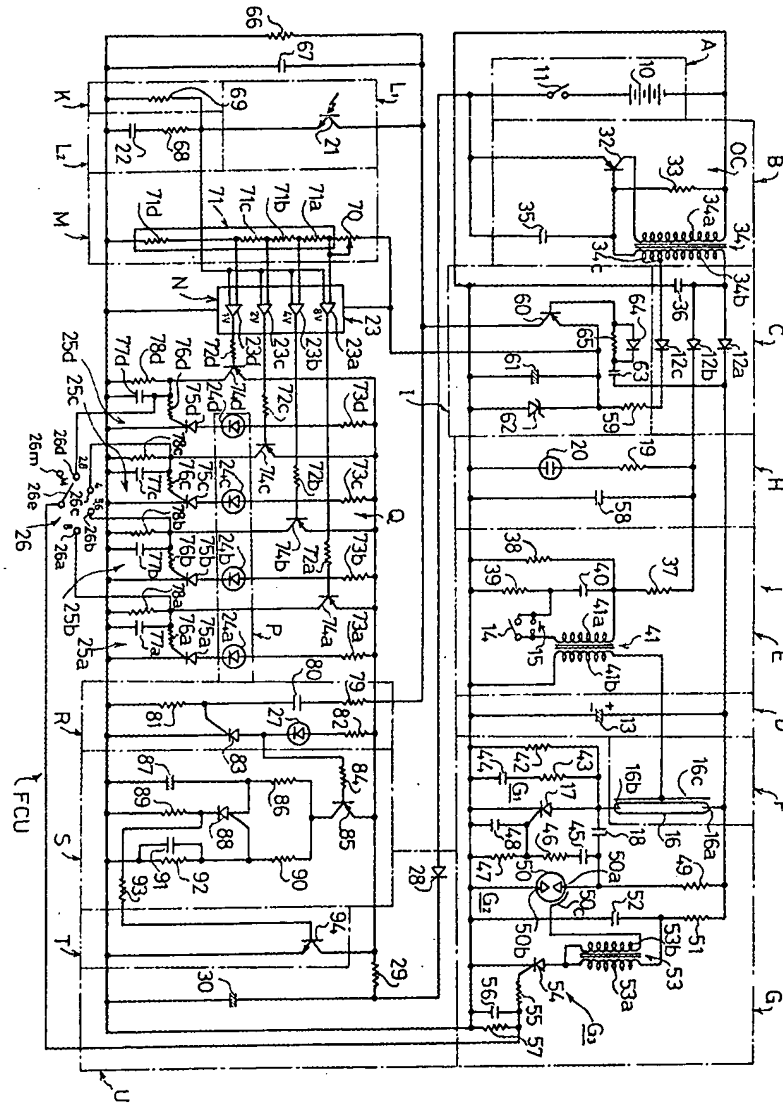

Fig.3

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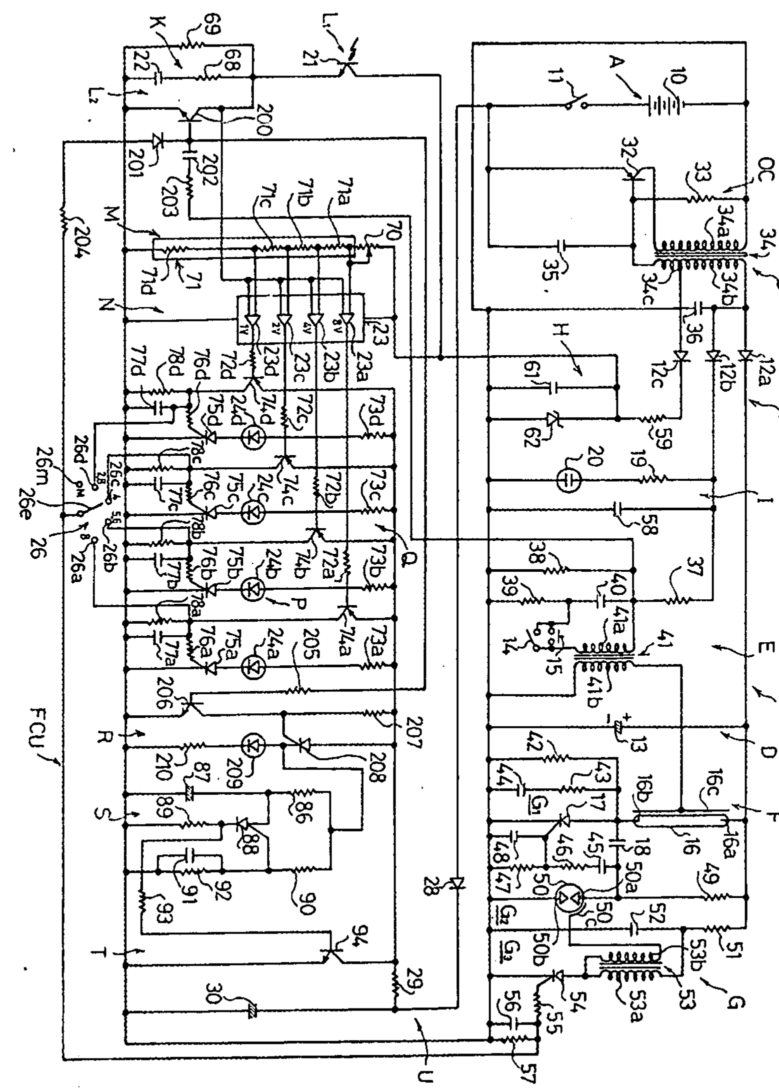

Fig. 4

SPECIFICATION
Electric Flash Device

The present invention relates to an electronic flash device, and more particularly to an electronic flash device which is used in conjunction with an optical device such as a camera.

In recent years, flashlight has been widely used in association with optical apparatus such as, for example, a camera. Particularly when flash is employed in photography, control of the light output is very important. In an automatic flash which is employed in photography the flashlight is terminated when a measure of the light reflected from an object to be photographed attains a predetermined value.

The reflected light is, however, of low intensity if the object is dark or if the distance from the object to the flash device is long, so that the automatic control may not be activated. Moreover, if the object is dark or far away, it is difficult to judge the distance to the object correctly and consequently difficult to decide on an appropriate setting of the camera's diaphragm. Contrariwise, when the object is white or the distance from the object to the flash device is very small, the intensity of the reflected light quantity is excessive and the automatic light control is liable not to operate correctly.

It is, accordingly, an object of the present invention to provide an improved flash device.

According to the present invention, there is provided an electronic flash device in substantially the terms of claim 1 hereinafter or any inventive sub-combination of the features thereof.

In the accompanying drawings:

Figure 1 is a diagram of an electronic flash device according to the present invention;

Figures 2A to 2D are operating characteristic curves of the flash device of Figure 1;

Figure 3 is a diagram of an electronic flash device of the present invention; and

Figure 4 is an electric diagram of a modification of the flash device shown in Figure 3.

In Figure 1 of the drawings is shown an electronic flash device according to the present invention. The electronic flash device has a flash unit FU for generating a flashlight and a flash control unit FCU for controlling the flashlight generated by said flash unit FU.

The flash unit FU comprises, substantially, a power supply, an electrical energy storing means, for storing electrical energy supplied from said electric power supply, a flashlight generator for converting the electric energy stored in said electric energy storing means to light energy, a trigger for said flashlight generating means, and a flashlight control for controlling the output of light.

The power supply comprises a direct-current power source including a low-voltage battery 10 and a power source switch 11 in series with the battery 10, a voltage converter B for converting the battery voltage to an alternating voltage and a rectifier C constituted by a diode 12.

The electric energy storing means D comprises a capacitor 13 for storing electric charge ready for supply to the flashlight generating means F, which principally comprises a flash tube. The trigger comprises a trigger signal generating circuit E for actuating the flash tube. The flashlight control means comprises a quenching circuit G, an indicating and trigger control circuit H for indicating that an electric charge is stored to a sufficient (predetermined) value and for controlling activation of said trigger signal generating circuit E, and a voltage generating circuit I to be described.

The flash control unit (FCU) comprises a sensor L_1 for sensing light originally generated from the flash tube circuit and thereafter reflected from an object to be photographed (not shown in the drawing) and being conductive in response to its illumination, an integrator circuit L_2 in which the charging time of a capacitor changes according to the conduction of the sensor L_1, a circuit J for adjusting the reset timing of the integrator circuit L_2, a reset circuit K, a reference voltage setting circuit M for setting a plurality of reference voltages, a detecting circuit in the form of a comparator circuit N receiving a voltage signal and a reference voltage signal of the reference voltage setting circuit M, an exposure-indicating circuit illuminating in response to an output of the comparator circuit N, an indication controlling circuit activated by a voltage signal supplied from the voltage generating circuit I, an actuation confirming circuit R actuating and rendering the indication controlling circuit to fire when the signal is supplied from the voltage generating circuit I of the flash unit FU, a timer circuit S for setting time interval of said indicating circuit P and an illumination resetting circuit T for resetting the illumination of the indicating members.

The voltage converter B may be in the form of an oscillator which feeds the main storage capacitor 13 by way of the rectifier C. The trigger signal generating circuit E has a triggering transformer and a trigger capacitor and operates either on operation of a switch 14, which is operated in synchronism with a camera shutter (not shown in the drawing) or when a "test" button switch 15 is operated. The flash tube 16 is connected in parallel with the main storage capacitor 13. The quench control circuit G is connected to a controlled rectifier constituted by a thyristor 17 by way of a commutation capacitor 18. The trigger control circuit H is connected to an indicating lamp in the form of a neon glow lamp 20 by way of a protecting resistor 19. The trigger control circuit H controls the trigger signal generating circuit E. The voltage generating circuit I is activated by an input signal from the trigger signal generating circuit E and applies a supply voltage to the sensor L_1, the integrator circuit L_2, the timing adjusting circuit J, the reference voltage setting circuit M, the

comparator circuit N, the circuit R and the timer circuit S.

The reset circuit K operates after a predetermined time interval when the flash tube 16 flashes and turns the integrator circuit L_2 OFF. The sensor L_1 comprises a phototransistor 21, which is connected to an integrating capacitor 22. The reference voltage setting circuit M comprises, substantially, a plurality of voltage dividing resistors. The comparator circuit N comprises a plurality of comparators 23*a*, 23*b*, 23*c* and 23*d*, each of which is activated by different operation voltages such as, for example, 8 volts, 4 volts, 2 volts and 1 volt. The comparators are connected to the integrator L_2 to receive a particular reference voltage from the circuit M. The indicating circuit P has a plurality of indicating elements in the form of light emitting diodes 24*a*, 24*b*, 24*c* and 24*d*. The indication controlling circuit comprises a plurality of switching circuits 25*a*, 25*b*, 25*c* and 25*d* which are connected to the light emitting diodes 24*a*, 24*b*, 24*c* and 24*d* and are operated by the comparators 23*a*, 23*b*, 23*c* and 23*d* respectively. The switching circuits 25*a*—25*d* are connected to the quenching circuit G by way of a changeover switch 26 and the indication controlling circuit is reset by the actuating signal of the quenching circuit G.

An actuation confirming circuit R is connected to an indicating element in the form of a light emitting diode 27 to illuminate the diode 27 in response to the voltage signal from the voltage generating circuit I of the flash unit FU.

The timer circuit S and the indication reset circuit T are, respectively, connected to the indicating circuit, the indication controlling circuit and the actuation indicating circuit R in parallel relationship. The timer circuit T is activated by a signal from the voltage generating circuit I. The indication reset circuit T is activated by a "time-up" signal from the timer circuit S and extinguishes the light emitting diodes 24*a*—24*d* of the indicating circuit and the light emitting diode 27. The smoothing circuit U comprises a diode 28 connected to the battery 10 and a smoothing capacitor 30 connected to diode 28 by way of a protecting resistor 29. The quench detecting circuit is connected to a light emitting diode 31 and the quenching circuit G.

The electronic flash device constructed as in the foregoing description operates as follows.

When the power source switch is closed, the voltage converter B starts oscillating and produces a high alternating voltage which is rectified by the rectifier C, electric charge being stored on the main storage capacitor 13. When the main storage capacitor 13 is charged to the predetermined voltage, the neon glow lamp 20 lights, indicating that the device is in readiness for the flash tube 16 to be fired and, further, the trigger controlling circuit H generates a control voltage. Under these conditions, the trigger signal generating circuit E can be activated to generate a trigger signal by the operation of the test button switch 15 or the synchronous switch 14 to enable the flash tube 16 to be fired. When the trigger signal generating circuit E activates, a control signal is supplied to the voltage generating circuit I. The voltage generating circuit I is activated in synchronism with the flash operation of the flash tube 16 by the control signal from the trigger signal generating circuit E.

By the activation of the voltage generating circuit I, a voltage is supplied to various parts of the flash control unit FCU, namely circuits J, K, L_1, L_2, M, N, R and S. The voltage smoothing circuit U smoothes the battery voltage and the smoothed voltage is applied to the indicating circuit and the indication controlling circuit.

The flashlight produced by the flash tube 16 illuminates the object to be photographed and is reflected from the object. The phototransistor 21 senses the reflected flashlight and becomes conductive accordingly. By the conduction of the phototransistor 21, electric charge is stored on the integrating capacitor 22 of the integrator circuit L_2 at a rate dependent on the conduction of the phototransistor 21. The voltage across the capacitor 22 is applied to the comparator circuit N and, at the same time, the reference voltages are also applied to the comparator circuit N from the reference voltage setting circuit M.

If the reference voltages of the comparators are as previously given by way of example, and the voltage across the capacitor 22 is 4 volts, the comparator elements 23*b*, 23*c* and 23*d* activate. The indication controlling circuits 25*b*—25*d* is operated by the output signals fromthe comparator circuit N, and thereby the indicating elements 24*b*—24*d* illuminate to indicate the output of the flash tube 16. The setting of the circuit may, for example, by such that the circuits 25*a*—25*d* operate when the received light indicates that the diaphragm's relative aperture setting should be 8, 5.6, 4 and 2.8 respectively.

As is shown in Figure 1, the movable contact 26*e* is connected to the switch 25*b* by way of the stationary contact 26*b*. When the voltage signal of which the value is 4 volts is supplied to the comparator 23, the comparator elements 23*b*—23*d* activate to illuminate the light emitting diodes 24*b*—24*d*. Under these conditions the output signal of the comparator element 23*b* is supplied to the quenching circuit G by way of the changeover switch 26; thereby the thyristor 17 is made non-conductive and the flash tube 16 is extinguished. When the reflected light is less and the integrating value of the integration capacitor 22 is less than the diaphragm value F=5.6, the indication controlling circuits 25*c* and 25*d* activateto fire both of the light emitting diode 24*c* and 24*d*, or 25*d* activates to fire the only diode 25*d*. By observation of the diode corresponding to the setting of the switch 26 the photographer can easily confirm that, for example, the output of the flash tube 16 did or did not reach that appropriate for the selected diaphragm value and adjust the camera or flashlight accordingly.

When the reference voltages in the reference voltage setting circuit M are lower than the

voltage across the integration capacitor 22, the comparator N fails to operate. Accordingly, the voltage of the integrator circuit L_2 is forcibly lowered after the predetermined time interval when the voltage signal is generated from the voltage generating circuit I by using the timing adjusting circuit J. Further, when for example sunlight is received at the sensor L_1, the charging voltage of the capacitor 22 becomes higher than the reference voltage of the reference voltage setting circuit M, and the comparator circuit N operates erroneously. To prevent the error operation, the capacitor 22 is discharged by means of the discharging circuit K. The discharging circuit K is operated by means of supplying the output signal of the illumination controlling circuit Q by way of the changeover switch 26 when the illumination controlling circuit activates its operation.

The actuation confirming and detecting circuit R operates when the voltage signal is supplied to the circuit R from the voltage generating circuit I. By the operation of the actuation confirming and detecting circuit R, the light emitting diode 27 is illuminated. By the illumination of the light emitting diode 27, the operation of the flash unit FU can be confirmed. When the only light emitting diode 27 illuminates and all of the other light emitting diodes 24*a*—24*d* do not illuminate, the photographer can confirm that the flashlight of the flash tube 16 is insufficient.

The timer circuit S is also operated by the voltage signal supplied from the voltage generating circuit I. When the timer circuit S is activated by the voltage signal from the voltage generating circuit I, the pulse signal is supplied from the timer circuit S to the illumination resetting circuit T, after the preset time (such as 3 seconds) of the timer circut. By the application of the pulse signal from the timer circuit S to the illumination resetting circuit T, the circuit T operates to short-circuit the electric current to be supplied to the light emitting diodes 24*a*—24*d* and 27, and thereby the illumination of the light emitting diodes 24*a*—24*d* and 27 ceases.

Additionally, the operation of the quenching circuit G can be detected and confirmed by the illumination of the light emitting diode 31, since the quench detecting circuit V is operated by a signal from the circuit G and the diode 31 is fired by the operation of the circuit V. The diode 31 is extinguished by the operation of the illumination resetting circuit T.

Figures 2A to 2D are representative of the operating characteristics of the flash device of Figure 1. As is best shown by the curve l_1 of Figure 2A, it should be assumed that the illumination of the flash tube 16 commences at the time t_1 after the switch 14 or 15 is closed and ceases at the time t_3 (typically four milliseconds later). When the flash tube 16 begins to flash, the voltage generating circuit I begins to produce voltage (point A) and as is shown by a curve l_2, the voltage from the voltage generating circuit I is boosted up to 15 volts (point B). The boosted voltage is maintained during the given time interval such as, for example, about 5 millisecond as shown by curve l_3 in Figure 2B, and is, thereafter, damped as is shown by points C and D on the curve l_4.

The voltage across the capacitor 22 is shown by curve l_5 in Figure 2C. This voltage steadily increases during the interval t_1—t_2 as shown by the curve l_5 from points E to F. When this voltage attains the predetermined value as shown by the point F of the curve l_5, the comparator circuit N activates in order to operate the appropriate switch 25*a*—25*d* so that the quenching circuit operates to extinguish the flash tube 16 at approximately the time shown by the point F of Figure 2C. The voltage across the capacitor 22 decreases to zero by the conduction of the circuit K, since the electric signal is supplied to the circuit K by way of the switch 26. To the contrary, the charging voltage of the capacitor 22 becomes higher than 8 volts as is shown by l_6 of Figure 2C, when the circuit K is not activated and thereby the electric charge of the integration capacitor 22 is not discharged. In this case, when the voltage of the voltage generating circuit I shown by l_4 becomes lower than that of the capacitor 22 shown by the l_6, the comparator circuit N operates erroneously. To prevent the erroneous operation of the comparator N, the charging voltage of the capacitor 22 is made zero by means of the ON operation of the circuit K after the elapse of three seconds as is shown by the points E and G of the curve l_5.

Figure 2D shows the varation of voltage across the capacitor 22 when the intensity of reflected light is much lower. In this case, the voltage across the capacitor 22 decreases from a value corresponding to the point I to a value which corresponds to the point J, and becomes zero.

Although the capacitor 22 is discharged by short-circuiting the capacitor 22 after the predetermined time interval by adjusting the operation timing by means of the circuit J, the timing adjusting circuit J can be made conductive after the predetermined time interval such as, for example, 5 milliseconds from the point B by employing a timer element, as is shown in Figure 2B.

Figure 3 shows a second embodiment of the flash device in accordance with the present invention. According to the flash device shown in Figure 3, a voltage converter B comprises, substantially, an oscillator circuit OC. In more detail, the voltage converter B includes a switch element in the form of a transistor 32 of which the emitter is connected to a positive terminal of a battery 10 by way of a power source switch 11. Coupling transformer 34 including a primary coil 34*a* is connected to the battery 10 by way of the collector-emitter path of the transistor 32 and the power source switch 11, a resistor 33 between a positive terminal and a base electrode of the transistor 32, and a capacitor 35 connected between the emitter electrode and the base electrode of the transistor 32. One terminal of a

secondary winding 34*b* is connected to the base electrode of the transistor 32. The rectifier circuit C comprises diodes 12*a*, 12*b*, 12*c* and a capacitor 36. Anode electrodes of the diodes 12*a* and 12*b* are connected to a terminal of the secondary coil 34*b*, and an anode electrode of the diode 12*c* is connected to a tap 34*c* of the secondary coil 34*b*. The capacitor 36 is connected between the secondary coil 34*b* and the negative terminal of the battery 10.

An electric energy storing circuit D has a main storage capacitor 13 which is connected to the diode 12*a* of the rectifier circuit C and the negative terminal of the battery 10. A trigger signal generating circuit E comprises resistors 37, 38 and 39, a first trigger capacitor 40 and a first triggering transformer 41. The resistors 37 and 39 and the trigger capacitor 40 are connected between the diode 12*b* and the negative terminal of the battery 10, and the resistor 38 is connected to the trigger capacitor 40 and the resistor 39 in parallel relationship in order to be used as a by-passing resistor of the trigger capacitor 40. A primary coil 41*a* of the triggering transformer 41 is connected in parallel to the trigger capacitor 40 by way of a synchronous switch 41 and a test button switch 15. A flash tube circuit F has a flash tube 16 of which one electrode 16*a* is connected to the diode 12*a* of the rectifier circuit C and a trigger electrode 16*c* is connected to a secondary coil 41*b* of the first triggering transformer 41.

A quenching circuit G comprises a switching circuit G_1 controlling the flash tube circuit F, a quenching circuit G_2 for controlling the switching circuit G_1, and a quenching signal generating circuit G_3 for triggering the quench tube circuit G_2. The switching circuit G_1 comprises a first switching element in the form of a thyristor 17, a commutation capacitor 18, a commutation resistor 42, a resistor 43, capacitors 44, 45 and 48, and resistors 46 and 47 and is connected as shown. The quenching circuit G_2 includes a protecting resistor 49 and a quench tube 50 having a pair of main current conducting electrodes 50*a* and 50*b* and a trigger electrode 50*c*. The quench tube 50 is also connected to both electrodes 16*a* and 16*b* of the flash tube 16 and the main storage capacitor 16. The quenching signal generating circuit G_3 includes a protecting resistor 51 and a triggering capacitor 52. The capacitor 52 is connected between the diode 12*a* of the rectifier circuit C and the negative terminal of the battery 10 of the direct current power source circuit A. A primary coil 53*a* of the second triggering transformer 53 is connected to the trigger capacitor 52 by way of a second thyristor 54. Connected to a gate electrode of the thyristor 54 is a protecting resistor 55, a capacitor 56 for absorbing noise voltages, and a resistor 57.

In a trigger controlling and indicating circuit H, an indicating element in the form of a neon glow lamp 20 is connected to the smoothing capacitor 58 by way of a protecting resistor 19. A voltage generating circuit I comprises a switch in the form of a transistor 60 of which an emitter electrode is connected to the diode 12*c* by way of a resistor 59, and a stabiliser comprising a Zener diode 62 and a smoothing capacitor 61. A base electrode of the transistor 60 is connected to the diode 12*a* by way of a bias controlling member which comprises a diode 64, a resistor 65 and a capacitor 63. A collector electrode of the transistor 60 is connected to a load resistor 66 in parallel with a capacitor 67 and in parallel with a branch including a phototransistor 21.

The phototransistor 21 is connected in series with a resistor 68 and an integrating capacitor 22, and a resistor 69 is connected in parallel therewith to form a discharging circuit K. The integration circuit L_2 comprises the resistor 68 and the integrating capacitor 22. A reference voltage setting circuit M has a voltage divider 71 which is connected to the collector electrode of the transistor 60 of the voltage generating circuit I by way of a variable resistor 70. The voltage divider 71 has a plurality of series connected resistor elements 71*a*, 71*b*, 71*c* and 71*d*.

A comparator circuit N comprises a plurality of comparators 23*a*, 23*b*, 23*c* and 23*d*. Each of the comparators 23*a*—23*d* is set so as to operate at a different setting voltage, and is connected to a corresponding tap in the chain of resistor elements 71*a*—71*d* in the voltage divider 71 and to the integration circuit L_2. Each of the light emitting diodes 24*a*—24*d* is connected to a corresponding switching control circuit 25*a*—25*d* of an indication controlling circuit Q. In the indication controlling circuit Q, each of the transistors 74*a*—74*d* is connected to the corresponding comparator element of the comparator circuit N by way of resistors 72*a*—72*d*. The protecting resistors 73*a*—73*d* are connected, respectively, to thyristors 75*a*—75*d* by way of the light emitting diodes 24*a*—24*d*. A changeover switch 26 is used to change the duration of the flashlight generated by the flash tube 16. The changeover switch 26 comprises a movable contact 26*e*, a "manual" operation setting contact 26*m* and a plurality of stationary contacts 26*a*, 26*b*, 26*c* and 26*d*. In more detail, the contact 26*a* corresponds to the f8, the contact 26*b* corresponds to f4, the contact 26*c* to f2 and the contact 26*d* to f1. The changeover switch 26 is connected to the thyristor 54 by way of a protecting resistor 55. The diaphragm of the camera should be set corresponding to the setting of the switch 26.

The collector of transistor 60 is connected to a branch comprising a resistor 79, a capacitor 80 and a resistor 81 the junction of the capacitor 80 and resistor 81 being connected to the gate of a thyristor 83 which is in series with a light emitting diodes 27 and a resistor 82. The anode of the thyristor is connected to the base of a transistor 85 by way of a resistor 84. The emitter transistor 85 is connected to opposite terminals of a programmable unijunction transistor 88 by way of a resistor 86 and a resistor 90m and the terminals of the transistors 88 are connected to the

negative rail by way respectively of an integrated capacitor 87 for adjusting delay time, a resistor 89, and a circuit comprising a capacitor 91 and a resistor 92. The base of the transistor 88 is connected to the base of a transistor 94 through a protecting resistor 93. The transistor 94 is connected to a diode 28 and a smoothing capacitor by way of a protecting resistor 29 and the diode 28 is connected to the battery 10 by way of the power source switch 11.

In operation, when the power source switch 11 is closed, the voltage converter B begins oscillating and thereby a high voltage is induced at the secondary coil 34*b* if the coupling transformer 34. The alternating voltage is rectified by the rectifier circuit C, and electric charge is stored on the main storage capacitor 13. When the main storage capacitor 13 is charged to the predetermined voltage, the neon glow lamp 20 lights, indicating that the device is ready for the flash tube 16 to be fired. Simultaneously, the triggering capacitors 40 and 52 are charged by the high D.C. voltage from the rectifier circuit C. In such conditions, the operation of the flash tube circuit F is initiated by the flash operation of the trigger signal generating circuit E in synchronism with the camera shutter opening operation.

The direct voltage rectified by the diode 12*a* of the rectifier circuit C is applied to the main storage capacitor 13, and the charging voltage of the main storage capacitor 13 is gradually increased. The charging voltage of the capacitor 58 is also increased by the application of the rectified voltage from the diode 12*b*. A direct current voltage rectified by the diode 12*c* is applied to the Zener diode 62 of the voltage generating circuit I to produce a constant voltage for circuits M and N and thereby the charging voltage of the capacitor 62 is made constant. The tap 34*c* of the transformer 34 is provided in order to obtain a relatively low voltage (such as about 15 to 20 volts). The transistor 60 is biased to be nonconductive by the voltage of the capacitor 63. In such condition, the charging voltage of the capacitor 61 is always applied to the comparator circuit N.

When the flash tube circuit F operates, the electric charge of the capacitor 63 (as well as that of the main capacitor 13) is discharged toward the flash tube 16. By the discharge of the capacitor 63, a negative voltage is applied to the base electrode of the transistor 60 to make it conductive. When the transistor 60 is made conductive, the terminal voltage of the capacitor 61 is applied to the light receiving circuit L_1, and the actuation confirming circuit R. Under these conditions, the phototransistor 21 of the light receiving circuit L_1 senses the reflecting flashlight of the flashlight produced by the flash tube 16 and becomes conductive. By the conduction of the phototransistor 21, electric charge is stored on the capacitor 22, the voltage across which increases towards a predetermined value which (as in the first embodiment) represents quantity of light received and is determined by the setting of switch 26. The reference voltage setting circuit M produces a plurality of reference voltages to be applied to the comparator circuit N. In this instance, the reference voltage M is set so as to produce the reference voltages such as, for example, 8V, 4V, 2V and 1V for the comparators 23*a*—23*d* respectively.

When the voltage across the capacitor 22 attains the predetermined value such as 8 volts, all of the comparators 23*a*, 23*b*, 23*c* and 23*d* signal and all the transistors 74*a*, 74*b*, 74*c* and 74*d* become conductive. When the transistors 74*a*—74*d* become conductive, gate signals are supplied to the thyristors 75*a*, 75*b*, 75*c* and 75*d*, enabling the thyristors to be conductive. By the conduction of the thyristors 74*a*—74*d* of the illumination controlling circuit Q, all of the light emitting diodes 24*a*, 24*b*, 24*c* and 24*d* light. In the same manner, at least one of the light emitting diodes 24*a*—24*d* of the indicating circuit P lights, indicating the flashlight quantity in accordance with the charging voltage value of the integration capacitor 22 of the integrating circuit L_2. Namely, when the charging voltage of the capacitor 22 is 4 volts, the diodes 24*b*, 24*c* and 24*d* light and indicate the corresponding quantity of light. When the charging voltage of the capacitor 22 attains to 2 volts the diodes 24*c* and 24*d* light and, when the voltage of the capacitor 22 attains to 1 volt, the diode 24*d* lights, indicating the corresponding quantity of the flashlight produced by the flash tube 16.

Although the indication controlling circuit Q is designed so as to be operated by the output signal of the comparator circuit N in the flash device shown in the drawings, in accordance with the present invention, an external and another indication control unit may be used instead of the indication controlling circuit Q.

In the flash device shown in Figure 3, when the distance between the object to be photographed and the flash device is small, the operation of the integrating circuit L_2 is fastened by the resistor 68, and the charging voltage of the integration capacitor 22 is bypassed by the resistor 69 of the discharging circuit K.

The output signal of the comparator circuit N is also supplied to the quench controlling circuit G by way of the changeover switch 26. The quench controlling circuit G controls the flash timing and the flashing time duration of the flash tube 16 in accordance with the control signal from the comparator circuit N. In more detail, if the movable contact 26*e* is connected to the stationary contact 26*d* which corresponds to the element 23*d* of the comparator circuit N, the output signal of the element 23*d* is supplied to the quench controlling circuit G when the integrated voltage of the integration capacitor becomes more than at least 1 volt. By the control signal from the comparator circuit N, the thyristor 54 is triggered to be conductive. When the thyristor 54 is turned ON, the electric charge of the second triggering capacitor 52 is discharged

by way of the primary coil 53*a* of the second triggering transformer 53 and the thyristor 54. A high voltage pulse is produced at the secondary coil 53*b* as a trigger signal of the quench tube 50.

There are, of course, certain criteria that must be met in quench tube 50. To operate effectively the quench tube 50 must have a low impedance compared with the flash tube 16. The flash tube 16 has a minimum impedance of typically 1.5 to 2 ohms. Thus, the quench tube 50 should have an impedance near 0.1 ohm. To provide such low impedance, the quench tube 50 also should have a low gas pressure and a small electrode spacing. The electrode 50*a* and 50*b* must be capable of carrying a very high current for short time. The quench tube 50 must be capable of being triggered rapidly and easily into conduction over the range of voltage change across the flash tube during the flash. The quench tube 50 includes a trigger electrode 50*c* spaced midway between the two main electrodes 50*a* and 50*b*.

By the trigger signal supplied from the triggering transformer 53, the quench tube 50 of the quenching circuit G_2 is made conductive. When the quench tube 50 becomes conductive, the discharging current from the main storage capacitor 13 of the electric energy storing circuit D is by-passed by the quench tube 50 to stop the flash operation of the flash tube 16 of the flash tube circuit F, because the internal resistance of the quench tube 50 is smaller than that of the flash tube 16.

When the flash tube is extinguished the light emitting diode (such as 24*d*) is extinguished because the comparator circuit N ceases operation.

When the distance between the object and the flash unit is very short, superabundant light generated from the flash tube 16 due to the delay of the activation of the quenching circuit G. Thus, the phototransistor 21 senses the unnecessary light, and thereby the unnecessary electric charge is stored on the integration capacitor 22. Accordingly, the light emitting diode 23*c* operates in addition to the diode 23*d*. In thus manner, the comparator circuit N is operated erroneously.

On the other hand, when the photographing distance is very long, the quantity of the reflected light is less, and, therefore, less electric charge is stored on the capacitor 22. Accordingly the voltage across the capacitor 22 is so low that none of the light emitting diodes operate. In this case, under exposure is detected and confirmed, since the firing signal is applied to the thyristor 83 of the actuation confirming circuit R from the voltage generating circuit I and thereby the thyristor 83 becomes conductive and the diode 27 illuminates. When the changeover switch 26 is set for manual (non-automatic) operation, an adequate quantity of flashlight can be confirmed if all light emitting diodes 24*a*—24*d* illuminate even though the control signal is not supplied to the quenching circuit G. When the thyristor 83 becomes conductive, negative charge is applied to a base electrode of the transistor 85 of the timer circuit S and the transistor 85 becomes conductive. When the transistor 85 becomes ON, the programmable unijunction transistor 88 also becomes conductive and an ON pulse signal is supplied to a base electrode of the transistor 94, by the conduction of which all of the light emitting diodes are reset to be nonoperative.

Additionally, although the timing circuit means of the present embodiment is constructed such that the light emitting diodes 24*a*—24*d* and 27 are turned off after the given time interval, it is not always necessary for this to be so. They may be maintained conductive: to perform this, it is possible to make the indication controlling circuit Q to be in an OFF state by the next flash operation in order to maintain the light emitting diodes conductive.

Figure 4 shows a modification of the device of Figure 3. In the device shown in Figure 4, a discharging circuit K comprises a resistor 69 connected to the integrating circuit L_2 in parallel, a transistor 200 of which a collector-emitter path is connected to the integrating circuit L_2 so as to be in parallel relationship, a diode 201 connected between a base electrode of the transustor 200 and a gate electrode of a thyristor 54 of a quench controlling circuit M by way of a resistor 204, and capacitor 202 connected between the base electrode of the transistor 200 and a voltage generating circuit by way of a resistor 203. An actuation confirming circuit R comprises a transistor 206 of which a collector-emitter path is connected to the gate of a thyristor 208, which is in series with a light-emitting diode 209 and a resistor 210. A resistor 205 connects the bases of transistors 200 and 206 and the collector of the latter is connected to the positive rail by way of resistor 207.

In accordance with the device of Figure 4, when a power source switch 11 is made ON, voltage is applied continuously to the phototransistor 21 and a comparator circuit N. Accordingly, the integration capacitor 22 is by-passed and short-circuited by the transistor 200 before the flash operation of a flash tube 16. The transistor 200 is made conductive by the negative potential of the base electrode, when the flash tube 16 is not activated. When the flash tube 16 flashes, a negative voltage is applied to the base electrode of the transistor 200, and the transistor 200 is made non-conductive. When the transistor 200 becomes non-conductive, the capacitor 200 commences integrating and the comparator circuit N operates in accordance with the voltage of the capacitor 22.

In the circuit R, the transistor 206 is maintained conductive by the positive potential of the base electrode, when the flash tube 16 does not flash. When the flash tube operates, negative potential appears on that base electrode, and the transistor 206 becomes non-conductive. When the transistor 206 is non-conductive, a gate signal is supplied to the thyristor 208 through the resistor 207, and thereby the thyristor 208 is turned ON. By the conduction of the thyristor 208,

the light emitting diode 209 lights, indicating under exposure. When the thyristor 208 is conductive, current flows to capacitor 87 by way of a resistor 86, and electric charge is stored on the capacitor 87. The transistor 88 becomes conductive when the electric charge of the capacitor 87 attains to a predetermined value after the predetermined time interval such as three seconds. When the transistor 88 is conductive, the voltage is applied to the transistor 94 by way of resistor 93 to turn the transistor 94 ON. When the transistor 94 is conductive, the light emitting diodes 24*a*—24*d* and 209 are extinguished. Control signals are supplied to the transistor 200 of the discharging circuit K and a thyristor 54 of a quenching circuit G from the comparator circuit N. By the control signal from the comparator circuit N, the transistor 200 is made conductive to short-circuit the capacitor 200 and, at the same time, the quenching circuit G activates in order to extinguish the flash tube F. Thereafter normal operation of the circuit L_2 can recommence.

Claims

1. An electronic flash device comprising, in combination, a flash unit having electric power supply means including a direct current voltage power source, means for boosting voltage of said direct current power source and for storing electric energy, flash light generating member including a flash tube generating flash light, trigger signal generating means triggering said flash light generating member, and means for stopping flash of said flash light generating member when flash light quantity of said flash light attains to a predetermined value, and a flash control unit having light receiving means for receiving a reflecting light which is produced from said flash tube and is reflected from an object to be photographed, flash light quantity detecting means for detecting flash light quantity of said flash light generated from the flash tube by means of comparing an electric value obtained by integrating output of said light receiving means with reference voltage, means for indicating light exposure quantity in response to a plurality of outputs of said flash light quantity detecting means, and flash light quantity control means for controlling said flash light quantity of said flash light.

2. An electronic flash device comprising a flash unit having electric power supply means including a direct current voltage power source, means for boosting voltage of said direct current power source and for storing electric energy, flash light generating member including a flash tube generating flash light, trigger signal generating means triggering said flash light generating member, and means for stopping flash of said flash light generating member when flash light quantity of said flash light attains to a predetermined value, and a flash control unit having light receiving means for receiving a reflecting light which is produced from said flash tube and is reflected from an object to be photographed, flash light quantity detecting means for detecting flash light quantity of said flash light generated from the flash tube by means of comparing an electric value obtained by integrating output of said light receiving means with reference voltage, means for indicating light exposure quantity in response to a plurality of outputs of said flash light quantity detecting means, and flash light quantity control means for controlling said flash light quantity of said flash light, said flash unit further comprising a voltage generating member applying voltage to said light receiving means and said flash light quantity detecting means of the flash control unit, and said flash control unit further comprising means for maintaining operation of said indicating means during a predetermined time interval.

3. An electronic flash device as claimed in claim 1 wherein said power supply means further comprising a voltage converter circuit for boosting and converting an output voltage of said direct current power source to an alternating current voltage, a rectifier circuit for rectifying an alternating output of said voltage converter circuit, and electric energy storing circuit including a main storage capacitor for storing electric energy of a direct current voltage of said rectifier circuit as electric energy, and said means for stopping flash of the flash light generating member comprises a quench controlling circuit having a switching circuit turning on and off said flash tube of the flash light generating member, a quenching circuit for controlling said switching circuit, and a second trigger signal generating circuit.

4. An electronic flash device as claimed in claim 1 wherein said flash light quantity detecting means comprises a reference voltage setting circuit including a plurality of voltage dividing resistor, and a comparator circuit for receiving a plurality of reference voltage and charging voltage of an integration capacitor of said flash light quantity detecting means.

5. An electronic flash device as claimed in claim 1 wherein said indicating means comprises an indicating circuit lighting in response to output signals of said comparator circuit.

6. An electronic flash device as claimed in claim 5 wherein said indicating means further comprising an indication controlling circuit controlling said indicating circuit in response to the output signals of said comparator circuit.

7. An electronic flash device as claimed in claim 5 wherein said flashlight quantity control means comprising a changeover switch connected to said comparator circuit and a quench controlling circuit connected to said changeover switch.

8. An electronic flash device as claimed in claim 2 wherein said voltage supply means comprises a voltage generating circuit activated by operation of said trigger signal generating means and generatingvoltage signal.

9. An electronic flash device as claimed in

claim 2 wherein said means for maintaining operation of said indicating means comprises a timer circuit generating OFF signal after a predetermined time interval at the time when the voltage generating circuit generates voltage signal.

10. An electronic flash device as claimed in claim 2, further comprising an actuation confirming circuit for indicating the actuation of said flash unit.

11. An electronic flash device as claimed in claim 10, further comprising an indication resetting circuit for resetting an indicating circuit for indicating the flash light quantity of the flash member.

12. An electronic flash device as claimed in claim 3, further comprising a trigger controlling circuit activating only when a neon glow lamp lights.

13. An electronic flash device as claimed in claim 1, further comprising means for making the voltage of an integrating circuit of said light quantity detecting means approximately zero by feedbacking a flash stopping signal to said integrating circuit.

14. An electronic flash device as claimed in claim 1, further comprising means for making the voltage of an integrating circuit of said light quantity detecting means approximately zero after a predetermined time interval from a time point after flashing of said flash tube.

15. An electronic flash wherein the duration of the flashlight is controlled in response to light reflected from an object or scene illuminated by the flashlight, there being provided means for producing a signal representative of the reflected light, means for integrating that signal, comparators arranged to compare the integrated signal with a plurality of reference signal, a plurality of networks each controlled by a respective comparator and arranged to provide an indication of the correspondence of the integrated signal to a respective one of the reference signals and selector means for enabling a selected one of the networks to control a quenching circuit so as to provide quenching of the flashlight when the integrated signal corresponds to a respective reference signal.

16. An electronic flash substantially as hereinbefore described with reference to Figure 1 or Figure 3 of the accompanying drawings.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1981. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.